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BODY PIGMENTATION AND EGG PRODUCTION IN THE FOWL

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Communicated by C. B. Davenport, January 10, 1917

The recognition by both plant and animal breeders of the great economic value of any character by which superior individuals might be indirectly selected has been father to a widespread conviction that such characters actually exist.

In the main, beliefs concerning distinctive structural peculiarities of the heavier yielding cereals, the bodily dimensions or proportions of the best dairy animals, and the criteria by which the most prolific layers may be selected from the flock without recourse to trap nesting, rest solely on personal experience and judgment, instead of upon measurements and correlations. They have, therefore, little scientific value.

The quantitative work which has been done on both animals and plants indicates that for the most part there is little prospect of the selection of the economically important characters of yield in plants, milk production in cattle or fecundity in poultry on the basis of structural characters unimportant as such but correlated with economically important physiological characters.

In certain cases, the relationship between two physiological characters, one with and the other without economic value, may be much more intimate. The measurements of the correlations may then be not merely of theoretical interest to the physiologist but of very real economic significance.

The relationship between the intensity of yellow somatic pigmentation and egg production in antecedent periods of time may serve as an illustration of such characters.

Working on two years data covering trap nesting records for 309 and 375 White Leghorn birds respectively, we find the following results for the correlation between the percentage of yellow pigment in the ear lobe¹ and total egg production for the preceding year²:

For 1913-1914, r_{yE}	$= -0.5816 \pm 0.0253$
For 1914-1915, r_{yE}	$= -0.5271 \pm 0.0252$
Difference	0.0545 ± 0.0358

Within the limits of the probable errors of random sampling, the results for the two years may be considered identical.

Expressing the relationship in terms of straight line prediction equations, represented graphically in Figure 1, we find:—

For 1913-1914, $E = 204.754 - 1.459 y$,

For 1914-1915, $E = 212.058 - 1.416 y$,

where E = total eggs laid per year and y = per cent yellow in ear lobes. Since yellow has been recorded in units of 5% range, the actual difference in egg production associated with a difference of one working unit in pigmentation is about seven eggs.

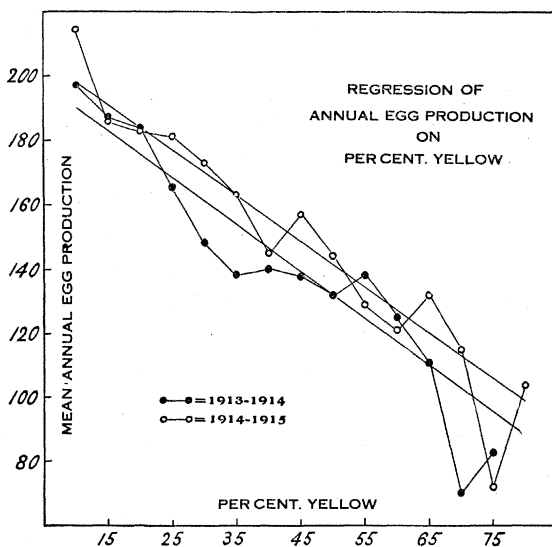


FIG. 1.

The practical significance of the differences in egg production indicated by this equation may be most readily seen from a little table showing the actual mean annual egg production of the birds grouped in classes of 15% range in ear lobe pigmentation.

PER CENT YELLOW IN EAR LOBES	1913-1914		1914-1915	
	Number of birds	Mean number of eggs	Number of birds	Mean number of eggs
10-20	83	187.0	81	185.1
25-35	67	148.2	72	172.2
40-50	111	136.7	119	148.4
55-65	46	132.1	90	126.9
70-80	2	76.5	13	111.5

It is clear that by selecting, in October, birds with 10 to 20% yellow it is possible to obtain a group which have averaged over 30 eggs more than the flock as a whole and over 50 eggs above the average of the class with 55 to 65% yellow. These differences are not merely very

great indeed, but the number of birds included in the heavy laying class is sufficiently large for practical selection operations.

The correlations for October pigmentation and egg production for the individual months, represented in Figure 2, are without exception negative in sign. The agreement between the results for the two years is very close indeed.³

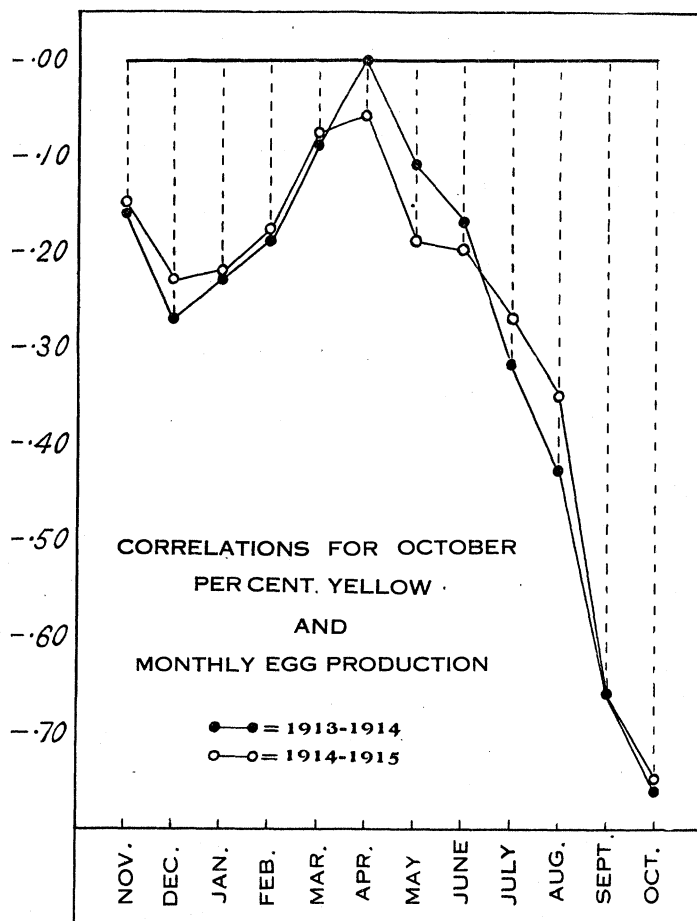


FIG. 2.

Thus there is not merely a strong negative correlation between the October ear lobe pigmentation and the egg production of the year as a whole, but there is a negative correlation between October ear lobe pigmentation and the egg records of each of the preceding twelve months.

The simplest physiological hypothesis to explain the demonstrated negative correlation between egg production and intensity of pigmen-

tation is that the egg yolk in its growth abstracts fat-soluble pigment from the food, thus precluding its localization in the body tissues, or that it actually withdraws the pigment from the tissues.

This view is supported by a number of lines of evidence. First, the correlation between October pigmentation and the egg production of the preceding months decreases (but, as is shown in Figure 2, not regularly) as the time at which egg production is measured becomes more distant from that at which the measurement of pigmentation was taken.

Again, in comparing pigmentation as measured in October of the second year with egg production in November of the pullet year, it is found that pigmentation decreases but slightly and irregularly, though apparently in a linear manner, with increasing egg production. In

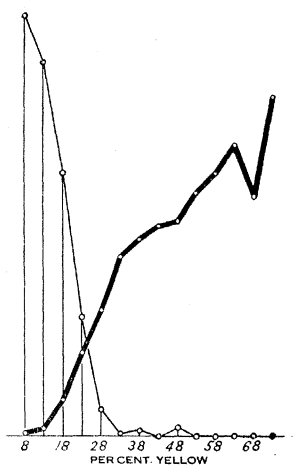


FIG. 3.

comparing October pigmentation with October egg production of the same (second) year, one notes that pigmentation decreases very rapidly as one passes from birds which have laid no eggs to those which have laid 1, 2, 3 or more eggs, but that this decrease soon falls off so that birds which have laid over 6 or 7 eggs are apparently sensibly alike in the amount of yellow which they exhibit.⁴

The same point may be brought out if a series of measurements be arranged to show the percentage of birds of various pigmentation classes which are 'laying' or 'not laying' at the time the color determinations were made.⁵ As shown in Figure 3 the percentage of the birds which are laying falls precipitously from 87.8% among those showing only 6 to 10% yellow (centered at 8% yellow) to practically zero for all grades of yellow above 30%. The average number of days since laying represented by the heavy line in Figure 3, is also a valuable indication of the direct relationship between egg production and pigmentation. Beginning with an average of only 0.4 day since laying in the 6 to 10% color class, the average length of time since laying increases rapidly from birds with smaller to those with larger amounts of yellow pigment.

Finally, the problem may be approached statistically as follows:

If the relationship between percentage of yellow and egg production be chiefly of a physiological nature, it is quite conceivable that the correlations between the October percentage of yellow and egg produc-

tion during the earlier months of the experiment may be largely the resultant of other interrelationships. Consider this possibility in detail.

Let r_{ye_1} , r_{ye_2} , r_{ye_3} , . . . $r_{ye_{12}}$ be the correlations between percent yellow in the twelfth month of the contest and egg production in the first, second, third . . . twelfth months respectively. Further let $r_{e_{12}e_1}$, $r_{e_{12}e_2}$, $r_{e_{12}e_3}$. . . $r_{e_{12}e_{11}}$ be the correlations between October and November, October and December, October and January . . . October and September egg productions. These constants have been shown to be positive throughout, indicating that birds excelling in egg production in October gave on an average higher productions in every other month of the year.

The application of the well known partial correlation formula for one variable, e_{12} , constant results in very material reductions in the values of r_{ye_1} , r_{ye_2} , r_{ye_3} , . . . $r_{ye_{11}}$. Thus the values of r_{ye_1} , r_{ye_2} , r_{ye_3} , . . . $r_{ye_{11}}$ must be in large part the resultants of $r_{e_{12}e_1}$ and $r_{ye_{12}}$, $r_{e_{12}e_2}$ and $r_{ye_{12}}$, $r_{e_{12}e_3}$ and $r_{ye_{12}}$. . . $r_{e_{12}e_{11}}$ and $r_{ye_{12}}$.

A discussion of the biological and biochemical literature, and a detailed statistical treatment of the data are appearing in *Genetics*, 1917.

¹ Ear lobe color has been measured in units of 5% range by means of the color top. Only yellow and white sectors were used.

² All birds entered the international Egg Laying Competition at Storrs, Connecticut, in November of their pullet year, and remained until the end of October of the following year. Pigment determinations were made near the end of October.

³ When the constants for the comparable months in the two years are considered in comparison with their probable errors, there is not a single difference which can be considered significant.

⁴ The biological inference to be drawn from this result would seem to be that the egg production of a recent period influences very profoundly the concentration of yellow pigment, so that there is a very rapid decrease in yellow pigment for each additional egg laid up to a certain point, beyond which the body pigment is relatively little reduced by extra egg production. Thus for October, the change in pigmentation is to be described by a curve, not by the slope of a straight line. The change in pigmentation is not proportional to egg production, but at first is very rapid and then falls off.

⁵ In collecting these data a bird which laid on the day the pigment determination was made or on a later day within the month was considered to be laying, and was recorded in the zero class, *i. e.*, no days since laying. If she laid on the day before the record was taken but not later she is recorded as one day since laying, and so on.

VARIABILITY OF GERM CELLS OF SEA URCHINS

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Communicated by A. G. Mayer, February 6, 1917

As a basis for an understanding of the changes in aging germ cells, it was necessary first to ascertain the normal variability, *i. e.*, the varia-